Adaptation measures related to water-related disasters to reduce the impacts of climate change due to global warming

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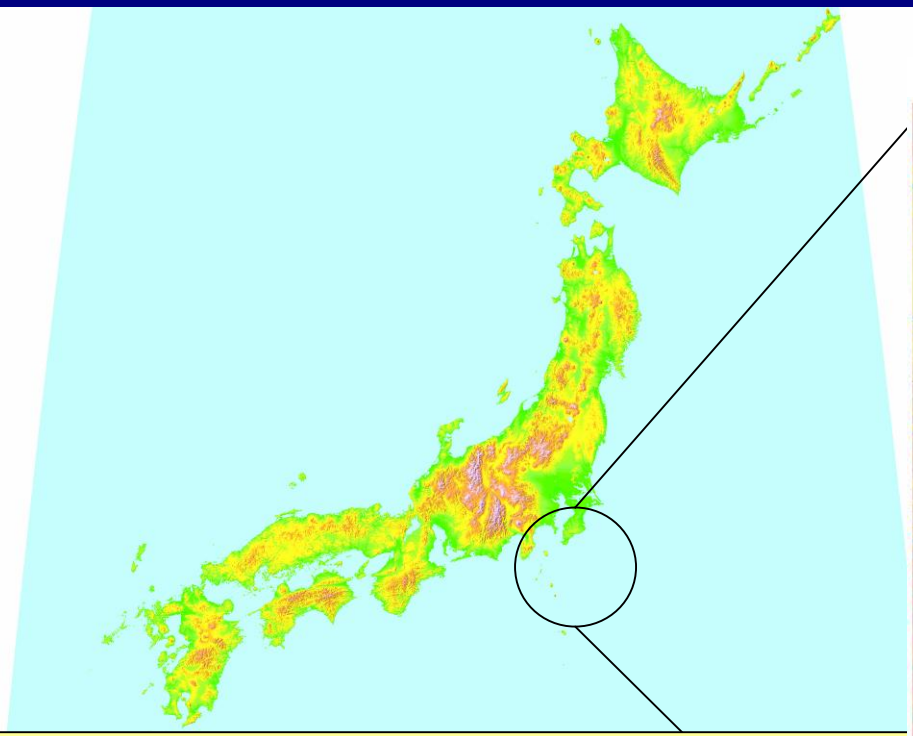
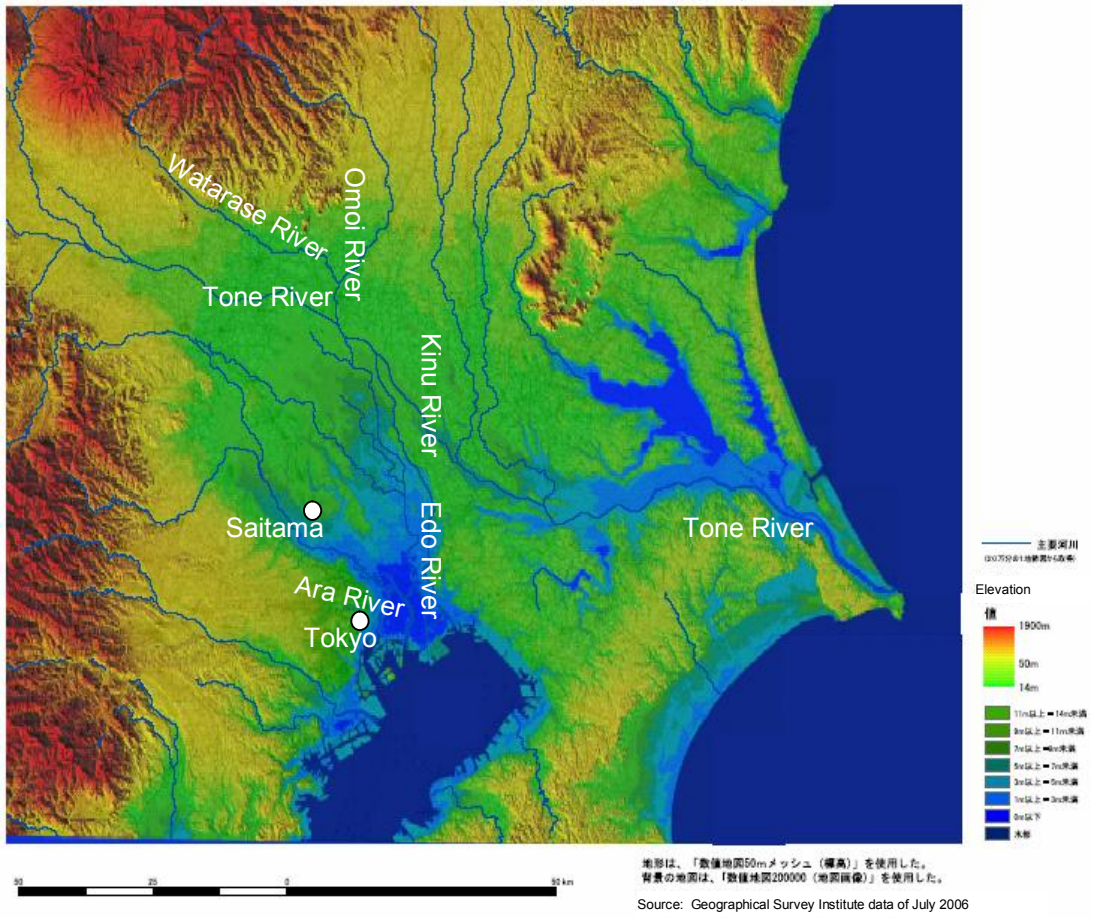
Japan is vulnerable to climate change.



(i) Land: A north-south stretch of land extending over a length of 2000 km
(ii) Four main islands: Four main islands are separated from one another by straits. There are also numerous small islands.
(iii) Backbone mountain range: Mountains run at the middle of the land.
(iv) Tectonic lines: Median and Itoigawa-Shizuoka Tectonic Lines run from north to south.
(v) Plains: Narrow plains are located along shorelines.
(vi) Weak soils: Most large cities are located on weak soils.
(vii) Earthquakes: About 10% of world's earthquakes occur in Japan.
(viii) Heavy rains: Japan is on the eastern edge of Monsoon Asian and is faced with the threats of heavy rains and typhoons. Rivers flow on steep slopes.
(ix) Snow cover: Sixty percent of land is located in snowy and cold areas.

Topography of the Kanto Plains from a viewpoint of flood control

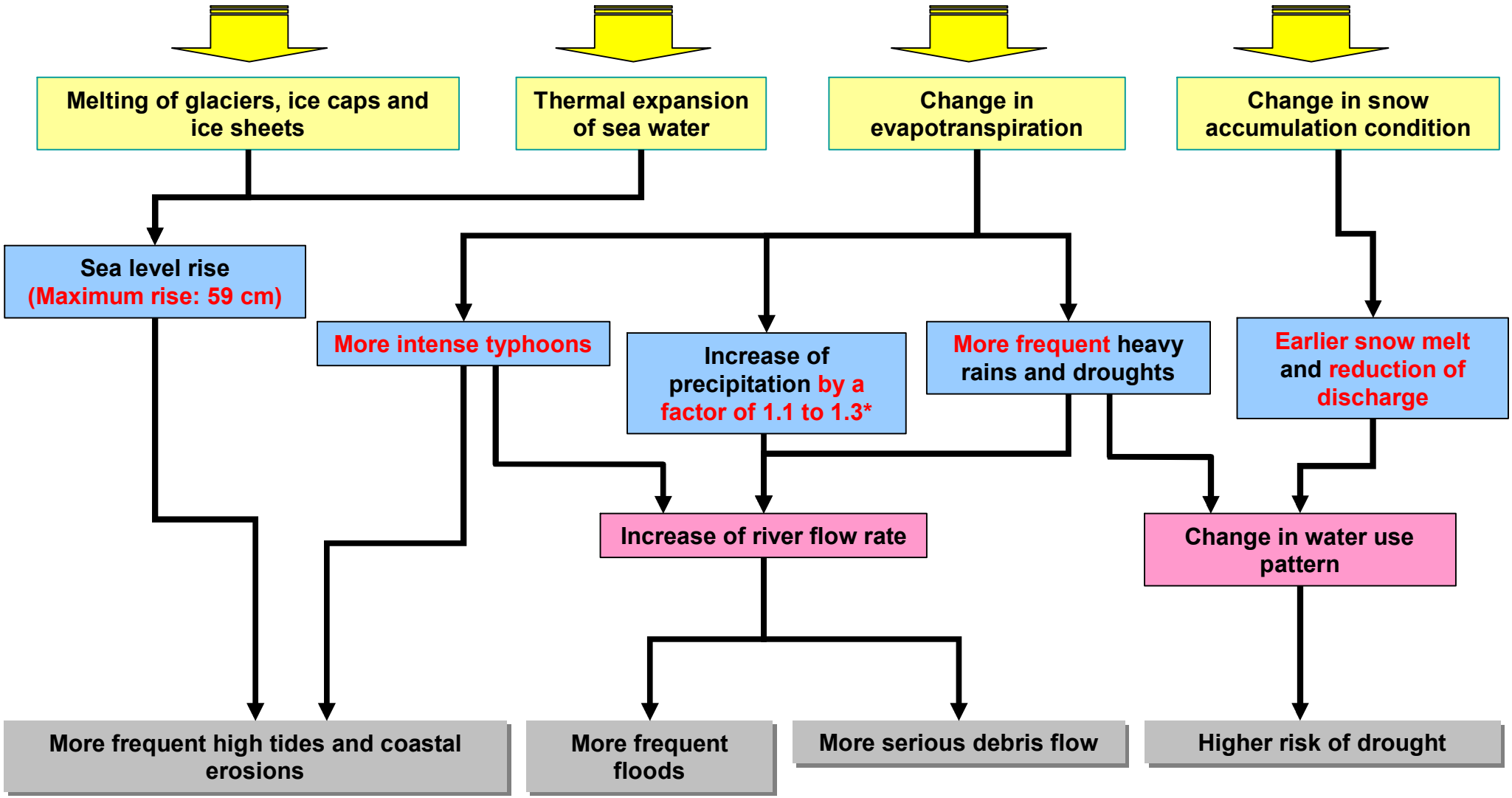


Source: Geographical Survey Institute data of July 2006

About 50% of population and about 75% of property on about 10% of land lower than water levels in rivers during flooding

Mechanism of global warming and climate change (impacts on water-related disasters)

Large volumes of greenhouse gas emissions cause CO_2 concentration in the air to rise and increase heat absorption, resulting in temperature rise. Thus, global warming occurs.
World's average temperature is projected to rise by 1.8 to 4.0℃ by 2010.



*Calculated by the Ministry of Land, Infrastructure and Transport based on the predictions of precipitation made by various research institutions

Item 1 Results of monitoring of climate change and its impacts

-Rises of global average air and ocean temperatures and of average global sea level attest to the warming of climate system.
-Global average surface temperature rose by 0.74℃ in the last 100 years.
-Sea level rose in synch with global warming.

Item 2 Cause of climate change

-The rise of global average surface temperature since the mid-20th century is highly likely to be attributable to the increase of man-made greenhouse gases.

Item 3 Expected climate change and its potential impacts

-A growth-oriented scenario highly dependent upon fossil energy sources will result in a rise of 4℃ in global average surface temperature and a rise of 0.26 to 0.59 m in sea level at the end of the 21st century according to the best available predictions.
-Frequency of heavy rains is highly likely to continue increasing.
-Intensity of tropical cyclones is highly likely to increase.
-Increases of frequencies and intensities of extraordinary meteorological phenomena, and the rise of sea level are expected to have adverse impacts on the nature and human system.

Asia
-Possibility of using freshwater will be reduced by 2050 in central, southern, eastern and south-eastern Asia, in large river basins in particular.
-Risk of inundation by floodwaters from rivers and the sea will increase in the megadelta areas in southern, eastern and south-eastern Asia.

Item 4 Options for adaptation and mitigation

-More effective adaptation measures than at present are required for reducing the vulnerability to climate change.

Category	Options and strategies for adaptation	Basic policy framework	Major restrictions and *opportunities*
Water	Increase of rainwater intake, development of water storage and conservation techniques, recycling of water, desalination and increase of efficiency of water use and irrigation	Domestic water resources policy, integrated management of water resources and control of water-related disasters	Financial, manpower and physical barriers, *integrated water resources management, synergy with other sectors*
Infrastructure and habitation	Reinforcement of embankments, jetties against high tides and sand dunes, land acquisition and construction of lakes and marshes to moderate sea level rises and floodwater entries	Considerations of climate change and criteria and regulations on which design is based, land use policy, construction codes and insurance	Financial and technical barriers, possibility of using space for transport, comprehensive policy and management, *synergy with sustainable development goals*

-Increases of global greenhouse gas emissions will be offset or reduced for the next decades through the implementation of adequate mitigation measures.

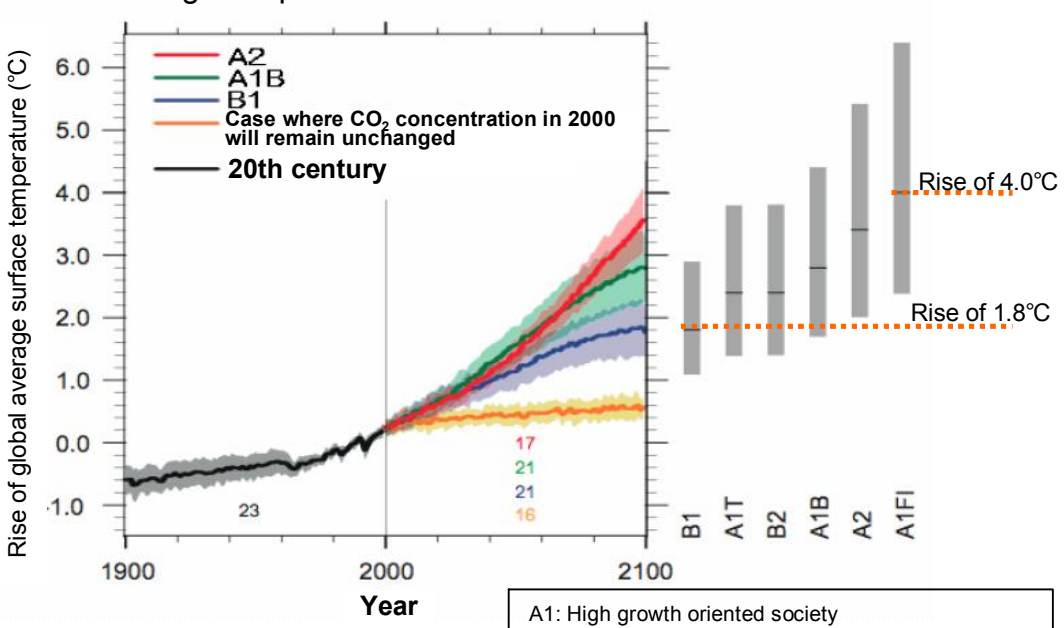
Item 5 Long-term perspective

-The five reasons for concern when considering climate change that were identified in the IPCC Third Assessment Report are increasingly stronger.
  (i) Increasing levels of risks to unique and threatened systems such as polar and high mountain communities and ecosystems
  (ii) Increasing levels of risks of extreme meteorological events such as droughts, heatwaves and floods
  (iii) Greater impacts and vulnerabilities for the regional and social groups vulnerable to climate change
  (iv) Benefits from global warming are expected to peak at lower temperature, and damage will be higher as global warming progresses. The costs of impacts of global warming are expected to increase with time.
  (v) Increasing levels of risks of climate change such as sea level rise and accelerated reduction of ice sheets
-Neither adaptation nor mitigation alone is sufficient. They can, however, significantly reduce the risks of climate change by complementing each other.
-Sea level rise due to global warming is inevitable.

Rises of temperature and sea level

-Temperature is expected to rise by about 0.2℃ per decade in the next 20 years.
-Global average surface temperature is expected to rise by 1.8 to 4.0℃ in 100 years' time from now.
-Global average sea level is expected to rise by 18 to 59 cm in 100 years' time from now.
-Global warming and sea level rise will continue over several centuries even if green house gas emissions are controlled.

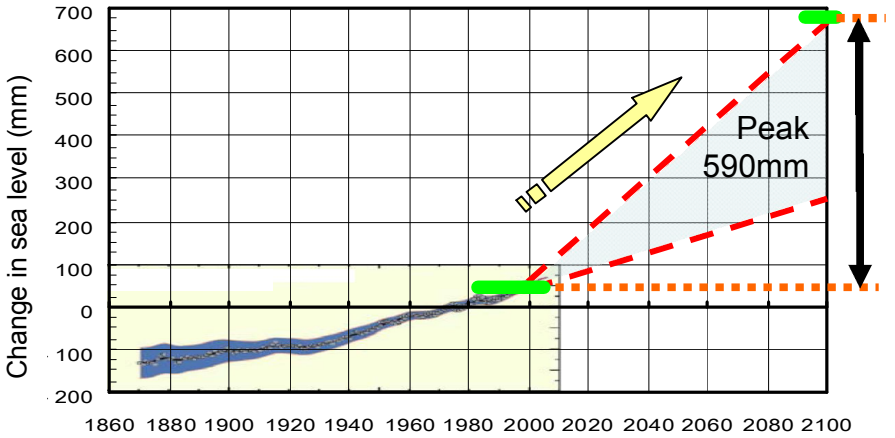
・ Average temperature



A1: High growth oriented society
A1FI: Dependent on fossil energy sources
A1T: Dependent on non-fossil energy sources
A1B: Emphasis on the balance among various energy sources
A2: Multipolarized society
B1: Sustainable growth oriented society
B2: Emphasis on regional initiatives

Source:
IPCC AR4 WG1 (Working Group 1) Summary for Policymakers (Japan Meteorological Agency)
-Solid lines indicate rises of global average surface temperature in each scenario identified using multiple models.
-Shaded areas indicate the range of standard deviations of average annual temperature for each model.

・ Average sea level



Source: Data prepared by the River Bureau based on the IPCC AR4 WG1 Report

・ Rises of average temperature and sea level at the end of the 21st century

	Society achieving both global environmental protection and economic development	Society achieving high economic growth dependent on fossil energy sources
Temperature rise	About 1.8℃ (from 1.1℃ to 2.9℃)	About 4.0℃ (from 2.4℃ to 6.4℃)
Sea level rise	Sea level rise	2 6 ~ 5 9 c m

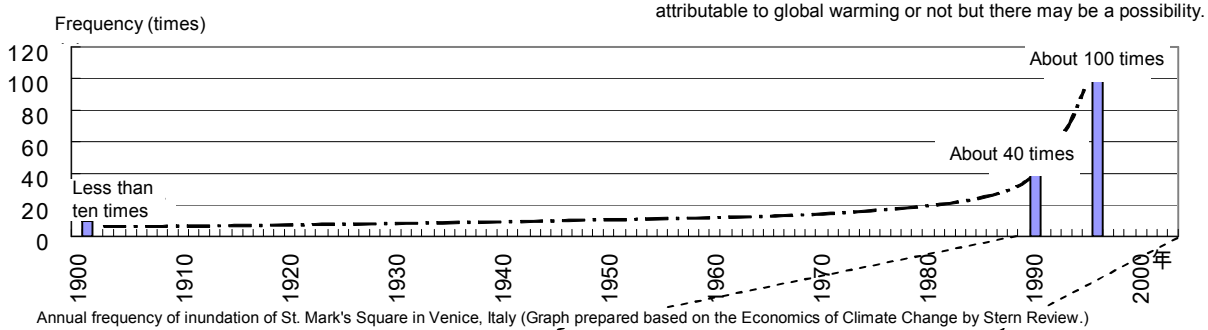
Source: IPCC AR4 WG1 Report

Impacts of sea level rise:
Increase of areas below sea level, and of risks of inundation due to high tides

Increase of risks of inundation due to high tides

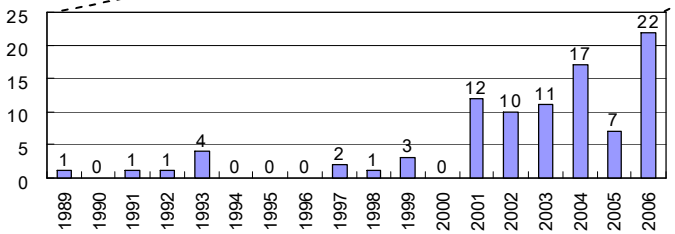
*At present, it is not clear whether the increase of inundation risk is attributable to global warming or not but there may be a possibility.

-St. Mark's Square in Venice was flooded with water less than ten times a year at the beginning of the 20th century. Ground settlement and climate change later caused the frequency to increase to about 40 times a year by 1990 and to as many as 100 times a year in 1996.
-There is also a report of 250 times of inundation a year in 2006.



Annual frequency of inundation of St. Mark's Square in Venice, Italy (Graph prepared based on the Economics of Climate Change by Stern Review.)

The corridor of Itsukushima Shrine in Hiroshima was inundated in water less than five times a year in the 1990s. It was flooded about ten times a year in the 2000s. The frequency was 22 times a year in 2006 and is still increasing.

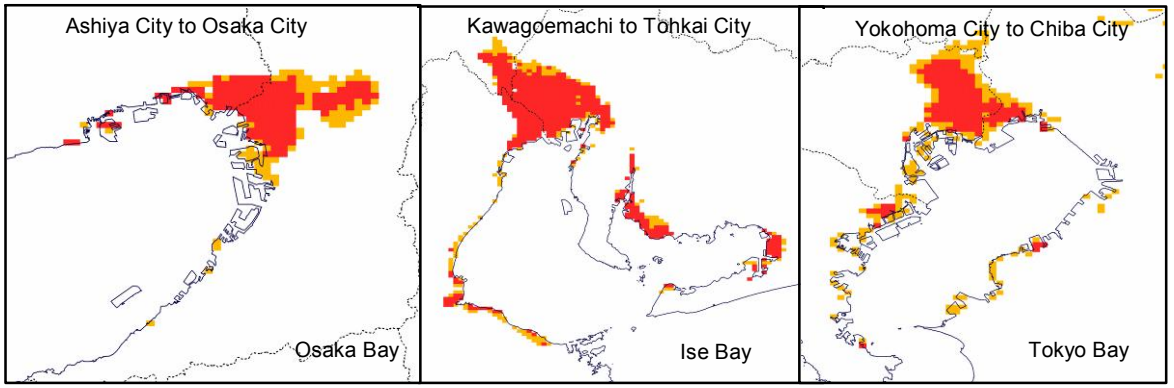


Annual frequency of inundation of the corridor of Itsukushima Shrine in Hiroshima (Graph prepared by the Chugoku Regional Development Bureau based on a diary of Itsukushima Shrine.)

Increases of below-sea-level areas in three large bay areas (Tokyo Bay, Ise Bay and Osaka Bay)

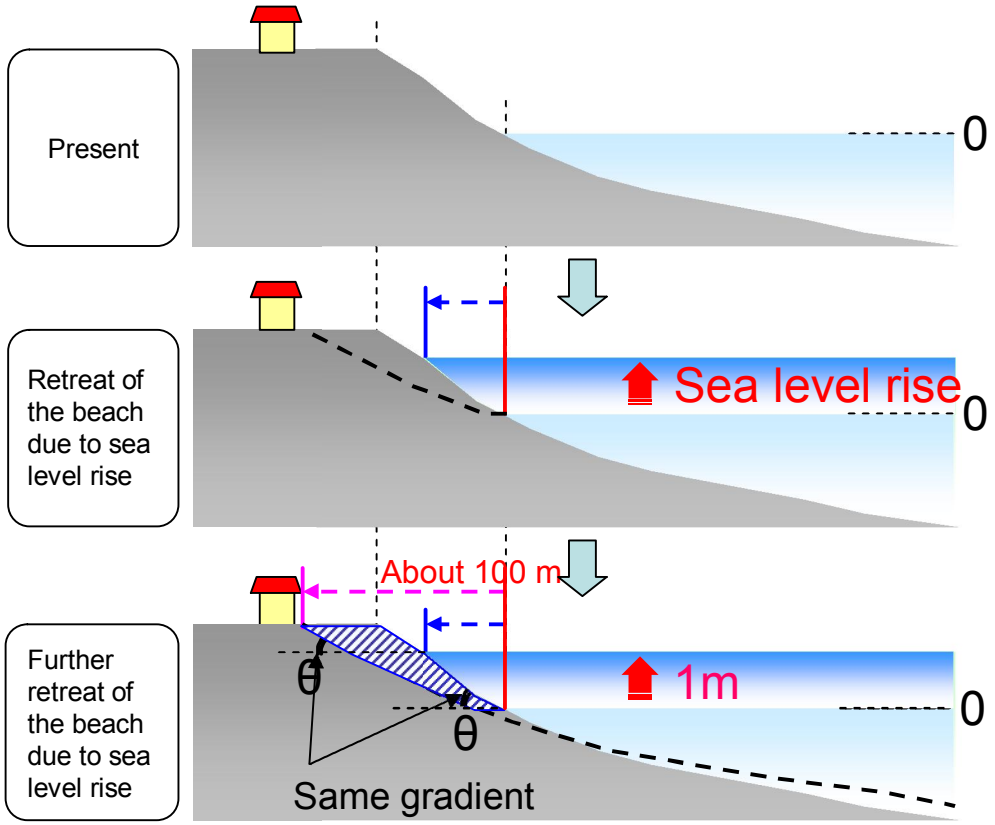
Areas with flood risks due to high tides will increase.

	Present	After sea level rise	Rate of increase
Area (km^2)	577	879	1.5
Population (in tens of thousands of people)	404	593	1.5



*Prepared by the River Bureau based on the national land-use digital information.
*Shown are the areas at elevations lower than sea level shown in a three-dimensional mesh (1 km x 1 km). Total area and population are based on three-dimensional data.
*No areas of surfaces of rivers or lakes are included.
*A premium of 60% is applied to the potential flood risk area and to the population vulnerable to flood risk in the case with a one-meter rise of sea level.

Impacts of sea level rise: Retreat or loss of beaches



Sea level rise (m)	0.3	0.65	1
Average distance of beach retreat	30.55	65.4	101.04
Percentage of eroded area	56.6	81.7	90.3

Prepared by the River Bureau based on the "Assessment of impacts of sea level rise on sandy beaches"

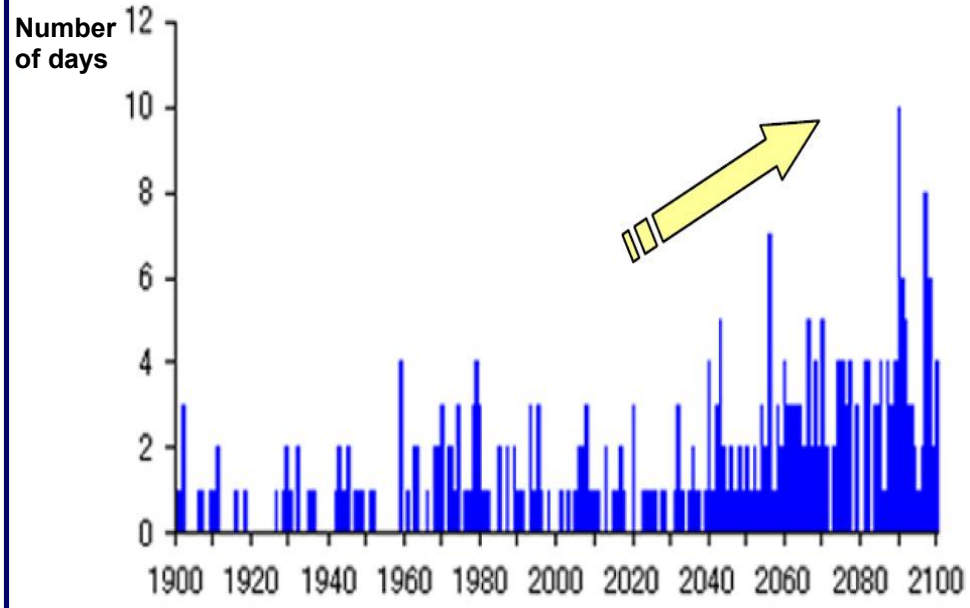
Coastal erosion in the Majuro Atoll of the Marshall Islands (Masaaki Nakajima, May 2001)

Source: Japan Center for Climate Change Actions

With sea level rise, the beach tries to achieve a stable gradient, so the shoreline retreats by a margin larger than the sea level rise.
With a one-meter rise of sea level, beach retreats by about 100 m. About 90% of beaches in Japan are vulnerable to erosion.

Increase of rainfall amount in summer

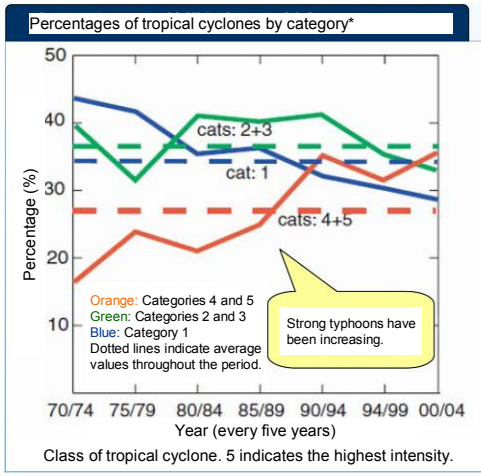
Year-by-year predictions of number of days of heavy rains in summer (daily precipitation of more than 100 mm)



Source: Press report of September 16, 2004 by a joint research team including the University of Tokyo.

The number of days of heavy rains with a daily precipitation of more than 100 mm is expected to increase from about three at present to a maximum of about ten per annum.

Increase of intensity of tropical cyclone



Numbers and percentages of categories-4 and -5 tropical cyclones

	Period			
	1975–1989		1990–2004	
	Number	%	Number	%
East Pacific	36	25	49	35
West Pacific	85	25	116	41
North Atlantic	16	20	25	25
Southwest Pacific	10	12	22	28
North Indian Ocean	1	8	7	25
South Indian Ocean	23	18	50	34

Source: Prepared by the Ministry of Environment based on the Outline of IPCC AR4 WG1 Report (official version).

-The percentage of strong tropical cyclones has increased over the past three decades.
-Categories 4 and 5 have increased also in the west Pacific area.
-The intensity of tropical cyclones is expected to increase further.

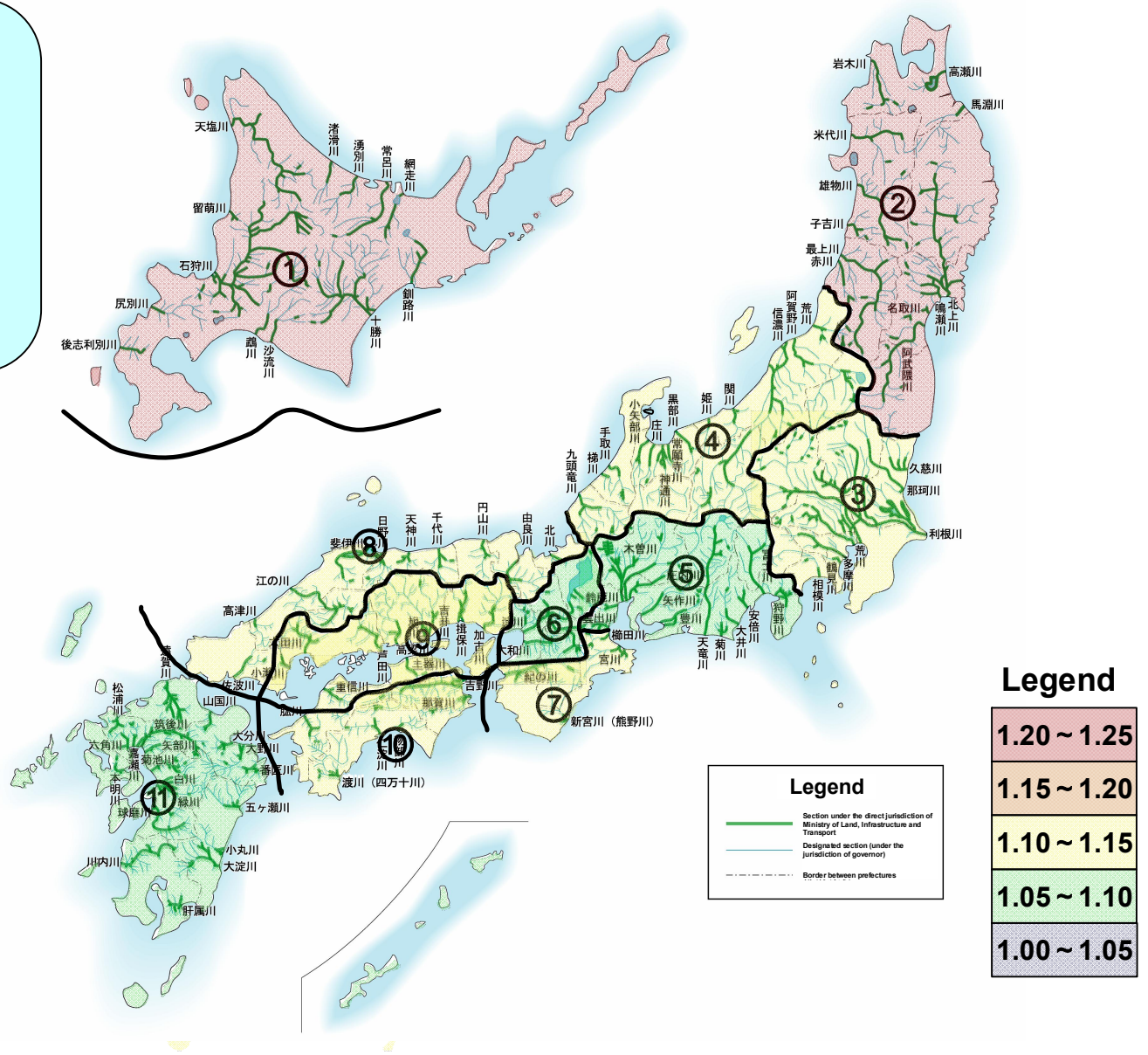
Areas with increased rainfall amount

Future rainfall amounts were predicted as a median value of

Average rainfall in 2080-2099 period
Average rainfall in 1979-1998 period

The above equation was obtained based on the maximum daily precipitation in the year at each survey point identified in GCM20 (A1B scenario).

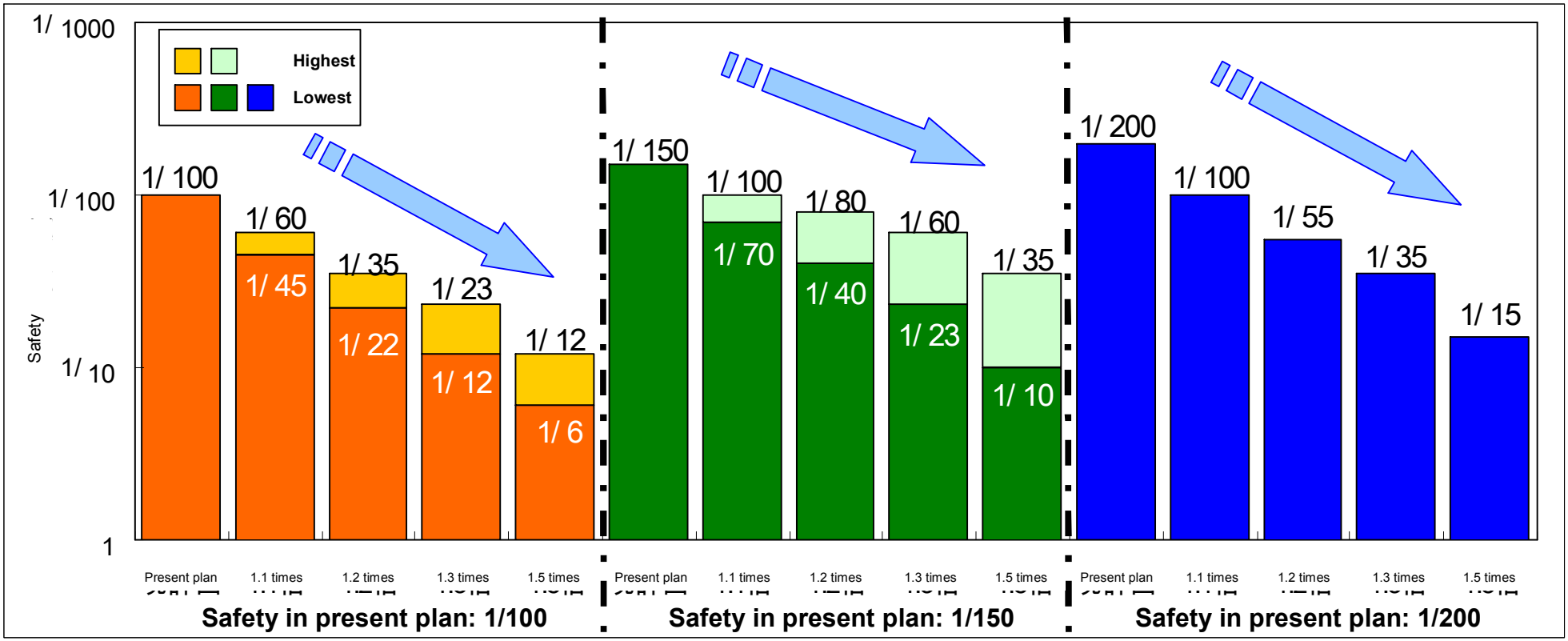
①	Hokkaido	1.24
②	Tohoku	1.22
③	Kanto	1.11
④	Hokuriku	1.14
⑤	Chubu	1.06
⑥	Kinki	1.07
⑦	Southern Kii	1.13
⑧	San-in	1.11
⑨	Setouchi	1.10
⑩	Southern Shikoku	1.11
⑪	Kyushu	1.07



Impacts of precipitation 100 years from now on safety against flood

Precipitation 100 years from now is projected to be about 1.1 to 1.3 times the present level. The highest projection may be 1.5 times.

Impacts of precipitation 100 years from now on safety against flood



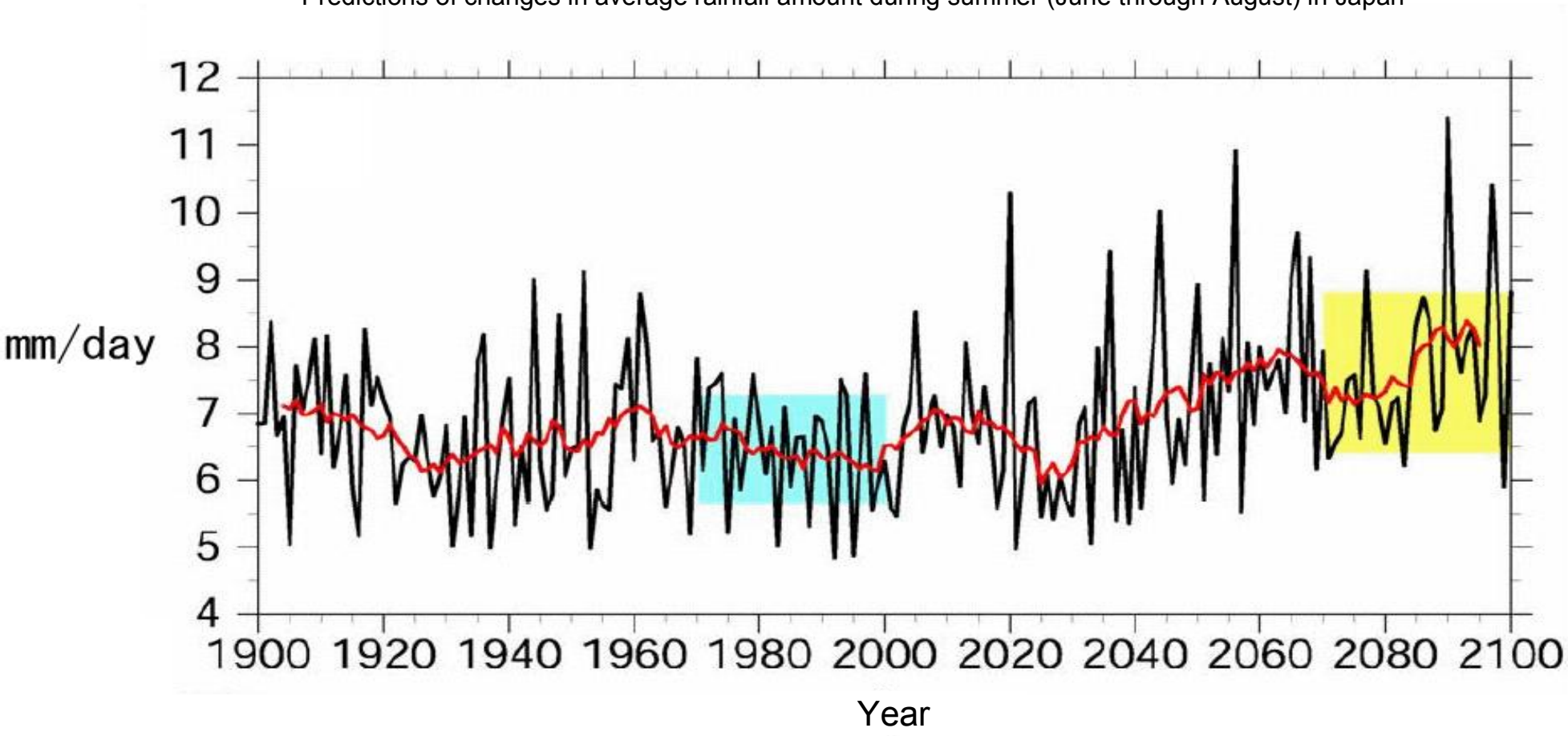
The safety designated in the present plan would substantially deteriorate based on the assumption of projected precipitation 100 years from now.

More frequent inundation and flooding

Frequent and more serious droughts: Increased range of variation of precipitation

-With the increase of rainfall amount, the range of variation also increases. The number of days with no rainfall also increases.
-The possibility of great floods also increases, and the possibility of droughts increases.
-Reduction of snow cover and earlier snow melt have impacts on social activities including rice cropping.

Predictions of changes in average rainfall amount during summer (June through August) in Japan



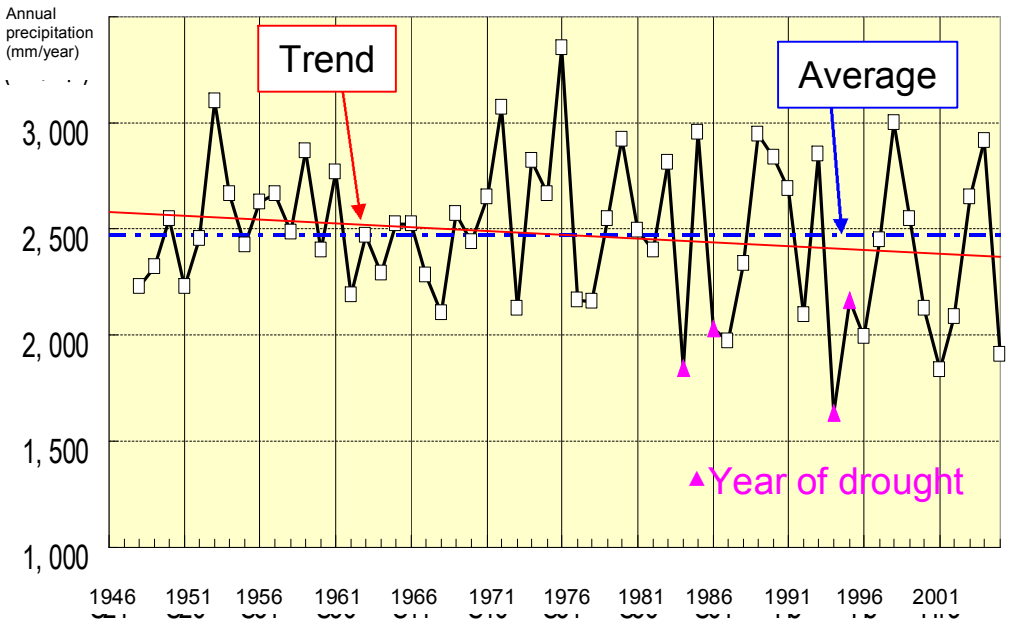
Source: Papers submitted by Masahide Kimoto to "World Day of Water -Water-related problems induced by climate change", a water resources symposium

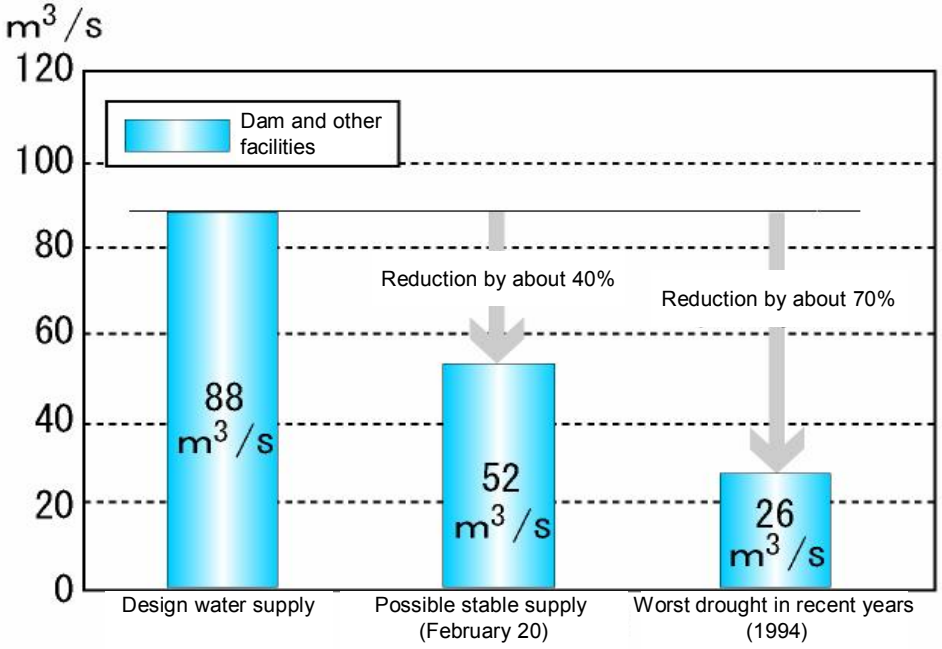
Frequent and more serious droughts: Deterioration of safety against droughts

- There has been a smaller rainfall amount in recent years and the range of variation has been lower than in the late 1940s through the late 1960s when dams and other facilities were constructed.
- As a result, stable water supply using dams has been decreasing.

Example in the Kiso River system

- ◇In recent years (in 1979 through 1998): Reduction of water supply below the design level by about 40%
- ◇Worst drought in recent years (1994): Reduction of water supply below the design level by about 70%



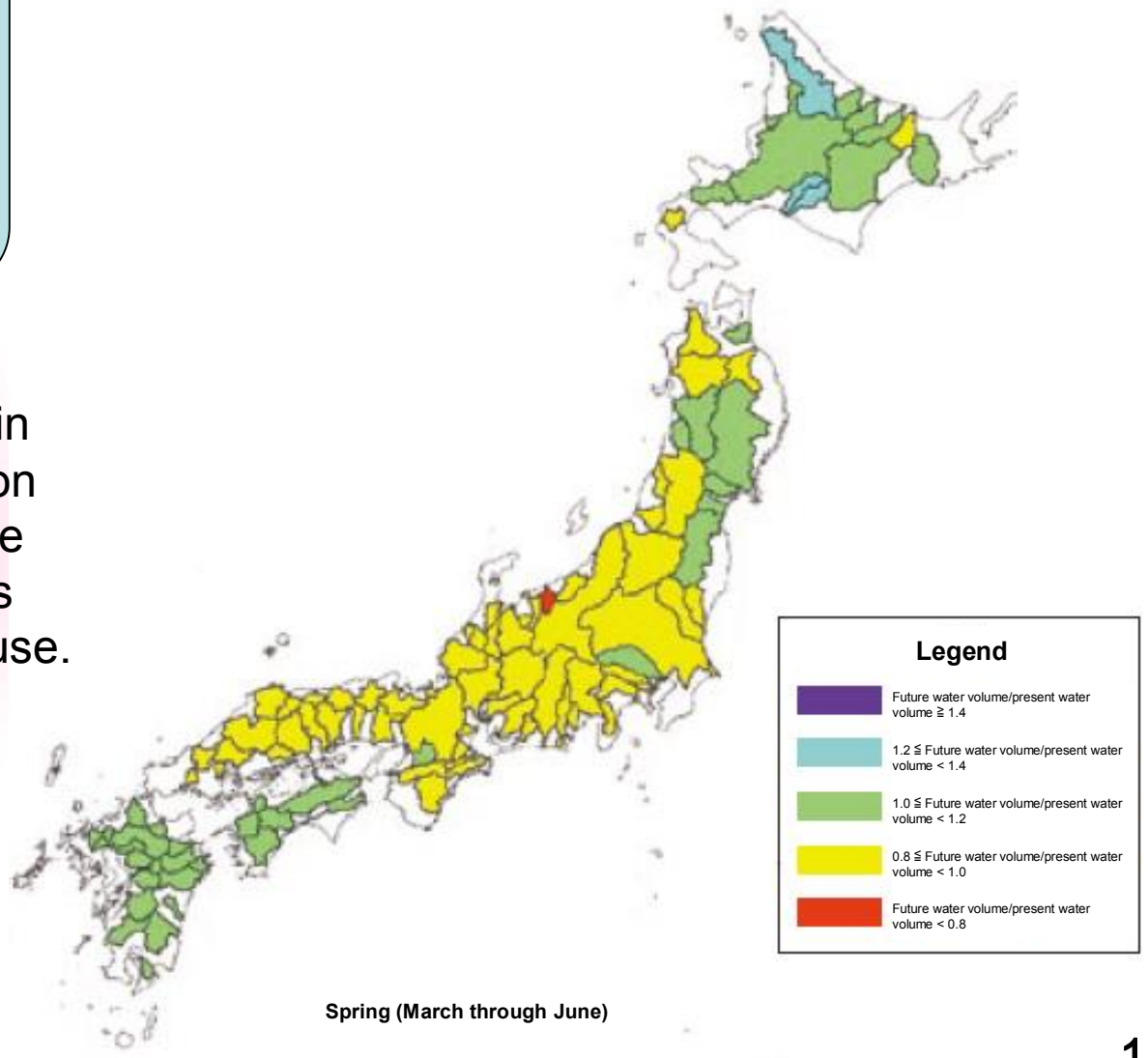


More frequent and serious droughts: Change in river flow rate due to global warming

Water falling to the earth's surface, or the sum of snowfall and rainfall in the March-June period, that impacts river flow rate will decrease in 100 years' time in numerous areas.

Reduction of river flow rate in the periods requiring irrigation water e.g. during the surface soil puddling in paddy fields may be detrimental to water use.

Present conditions in Class A rivers (1979 to 1998) and water falling on the surface in the future (2080 to 2099)

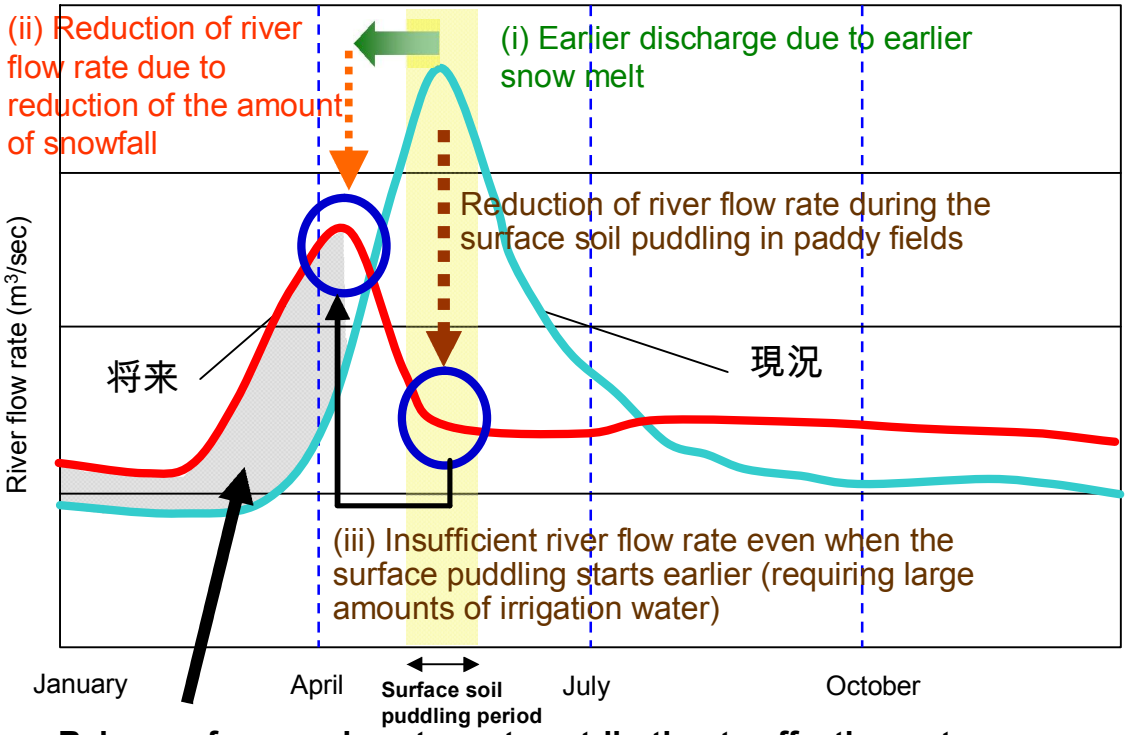


Spring (March through June)

Source: Water Resources in Japan 2007, Land and Water Bureau, Ministry of Land, Infrastructure and Transport

Frequent and more serious droughts: Change in river flow rate due to global warming

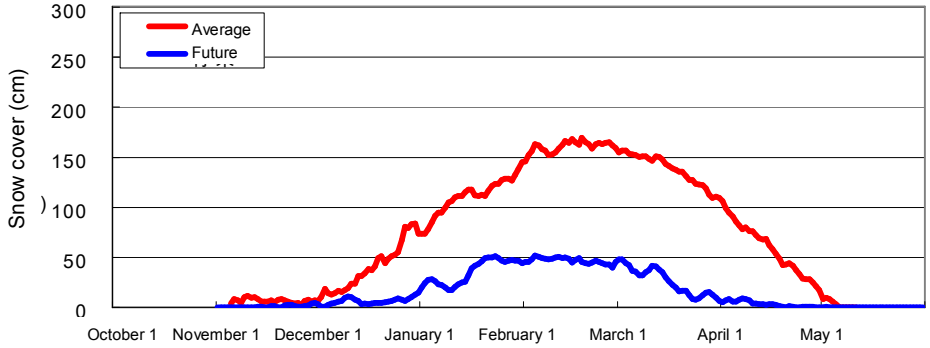
With global warming,
(i) earlier snow melt and (ii) reduction of snowfall induce changes in river flow rate, and
(iii) earlier surface soil puddling in paddy fields is expected to cause the annual water demand pattern to change and to have serious impacts on water use.



Release of reservoir water not contributing to effective water use
Where the reservoir is full, released water is not used effectively.

In the upper Tone River, snow cover is likely to be reduced considerably. That will accompany the reduction of river flow rate in the snow melt season or in early spring.

Change in snow cover in 100 years' time due to further global warming (Fujiwara)



*Prepared by Water Resources Department, Water and Land Bureau, Ministry of Land, Infrastructure and Transport based on Regional Climatic Model (RCM) 20, a global warming prediction model, developed by Japan Meteorological Agency.

Source: Water Resources in Japan 2007, Land and Water Bureau, Ministry of Land, Infrastructure and Transport

Climate change adaptation measures (against water-related disasters)

Climate change due to global warming is expected to induce the following phenomena in coastal and low-lying areas.

-More frequent heavy rains and more intense typhoons

⇒ Frequent and serious flood and sediment disasters

-Sea level rise and more intense typhoons

⇒ Frequent and serious high tides and coastal erosions

-Wider range of variation of rainfall intensity and change of river flow regime

⇒ Frequent and serious droughts

Combining CO_2 reduction measures (mitigation measures) with global warming control measures (adaptation measures) is important to further reduction of the risks of climate change.

○Basic direction of climate change adaptation measures

1. Adaptation measures to achieve "zero victims" should be considered because providing full protection from disasters is difficult.
2. In a nerve center like the Tokyo metropolitan area, intensive efforts should be made such as preventing the central government from ceasing functioning to minimize the damage.

○To provide protection from frequent floods expected to be caused by climate change due to global warming, flood control policy should shift from the conventional approach for ensuring safety only in rivers to the addition of measures in the basin such as the one allowing inundation.

How to study adaptation measures

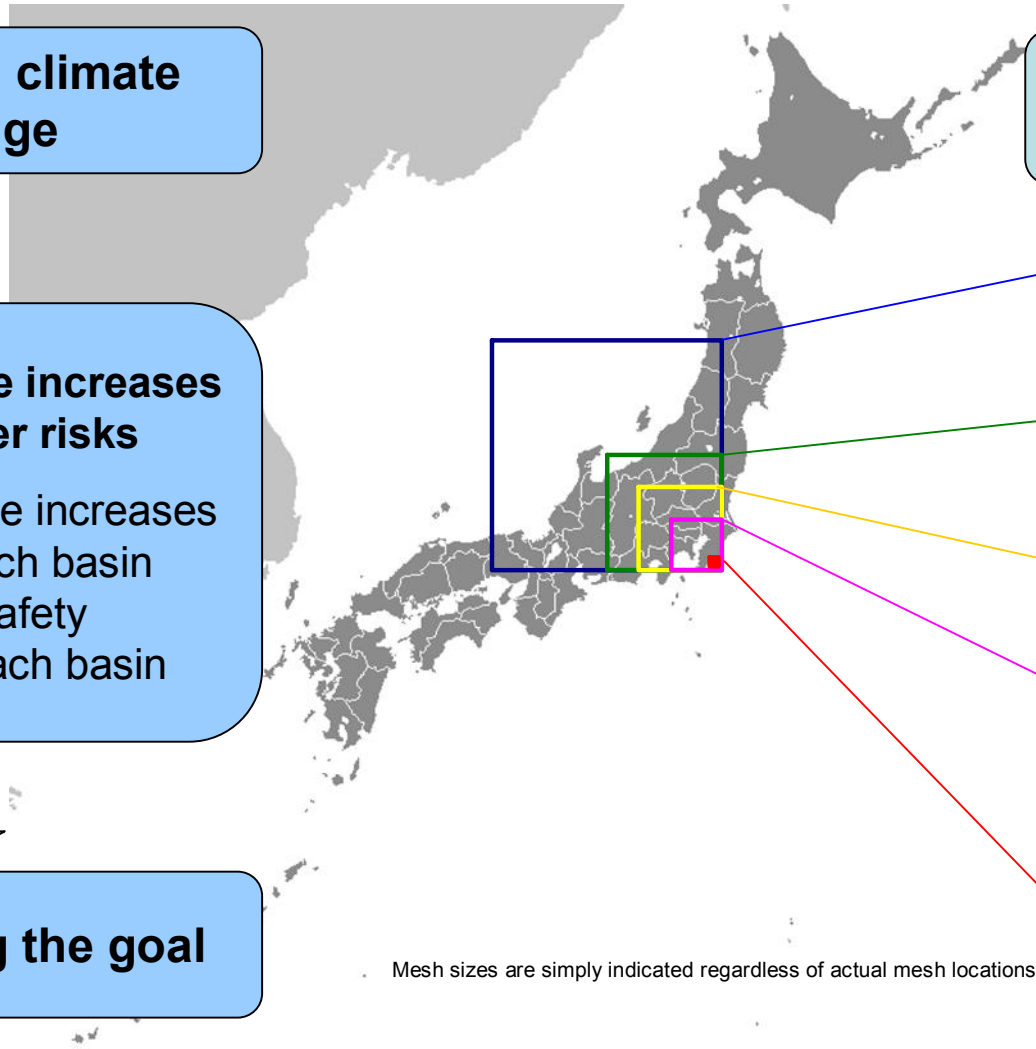
Predicting climate change

Predicting the increases of disaster risks

- Predicting the increases of floods in each basin
- Evaluating safety reduction in each basin

Re-defining the goal

Resolution of climate change prediction models has been enhanced year by year.



- IPCC First Assessment Report (1990): Horizontal resolution of about 500 km
- IPCC Second Assessment Report (1996): Horizontal resolution of about 250 km
- IPCC Third Assessment Report (2001): Horizontal resolution of about 180 km
- IPCC Fourth Assessment Report (2007): Horizontal resolution of about 110 km
- GCM20 and RCM20: Horizontal resolution of about 20 km

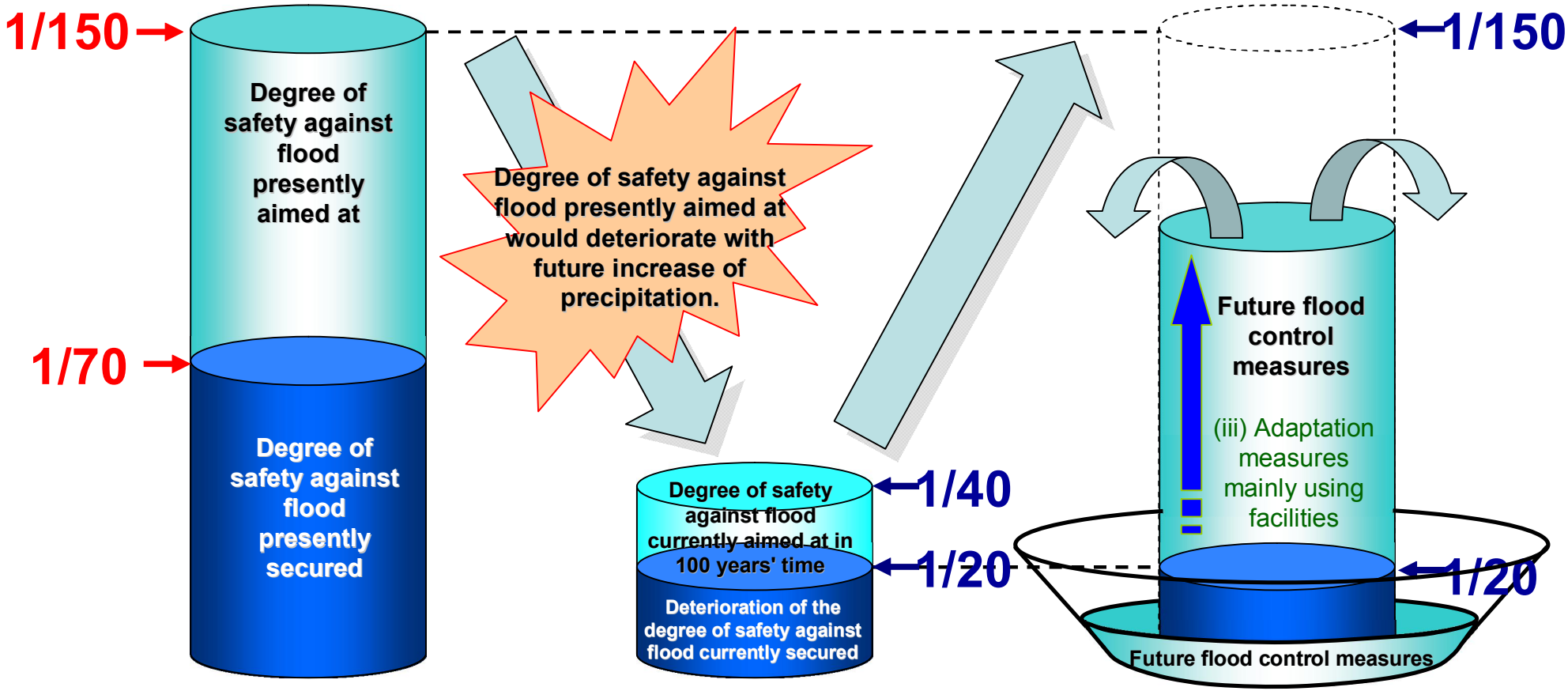
Mesh sizes are simply indicated regardless of actual mesh locations.

Prepared by the River Bureau

Limitations of adaptation measures

Red figures indicate present degree of safety against flood.

Blue figures indicate future degree of safety against flood.



(i) Adaptation measures based on regional development through such actions as restrictions on and review of land use
(ii) Adaptation measures centering around risk management

Basic direction of adaptation measures: Zero victims

Directions of adaptation measures

○ Define how to deal with increasing external forces using facilities.
Facilities-based adaptation measures will be taken such as the improvement of reliability, effective use or prolonging of lives of existing facilities and the construction of new facilities.

○ Set the level of protection according to the magnitude of the external force beyond the capacity of facilities.

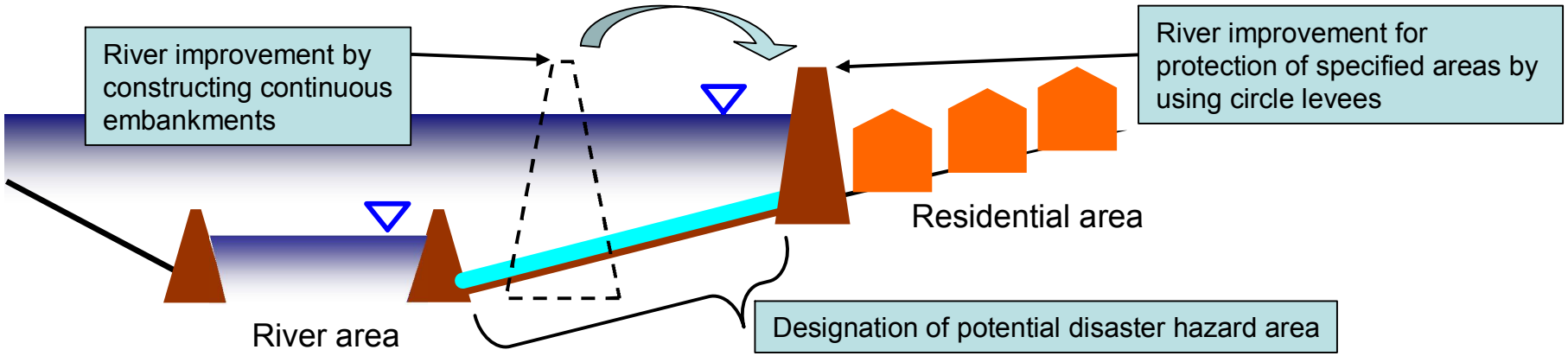
○ Determine adaptation measures accordingly to minimize damage.

1) Adaptation measures based on regional development through actions including the restrictions on and review of land use, such as a review of land use and ways of living and guidance in planning of inundation-resistant communities.
2) Adaptation measures based on risk management such as the development of a wide-area support system during a disaster, and studies of escape, relief and salvation, and restoration and rehabilitation activities.

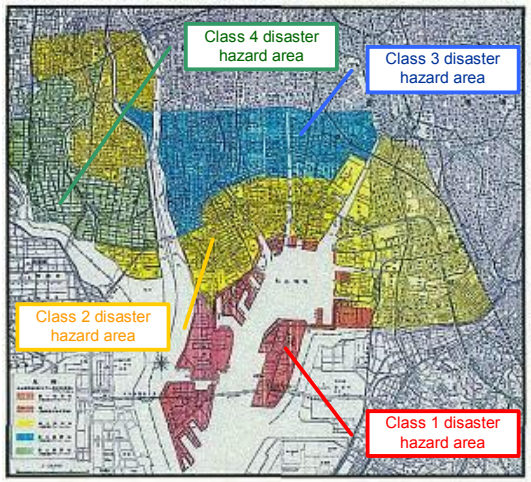
(i) Adaptation measures based on regional development through such actions as restrictions and review of land use

Response to floods that cannot be dealt with by facility-based measures, through land use or community development allowing inundation.

Shift to land use or ways of living that minimize damage

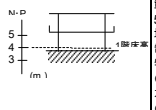
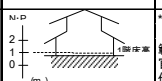
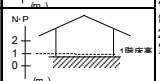
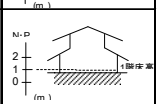


Restrictions on land use by designating potential disaster hazard areas



名古屋市臨海部防災区域図

Sample ordinance restrictions (Nagoya City)

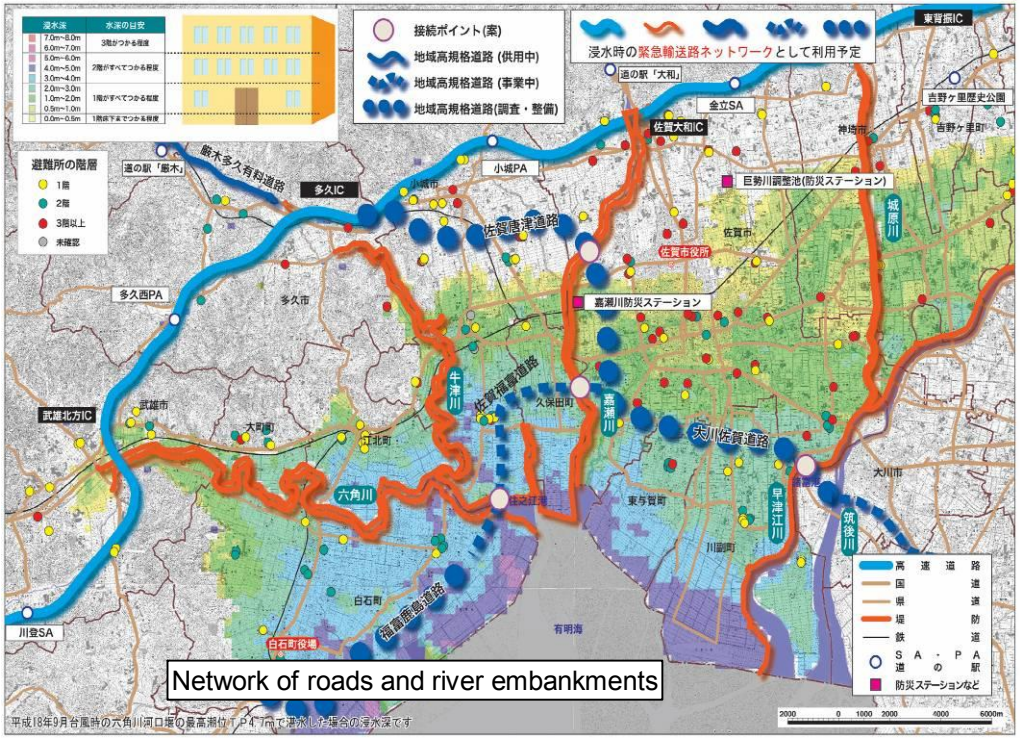
		1階の床の高さ	構造制限	図解	
第1種区域	市街化区域	N・P(+)4m以上	木造禁止		*建築物の建築禁止 範囲…海岸線・河岸線から50m以内で市長が指定する区域 制限…居住室を有する建築物、病院及び児童福祉施設等の建築禁止 木造以外の構造で、居住室等の床の高さをN・P(+)5.5m以上としたものについては建築可能
第2種区域	市街化区域	N・P(+)1m以上	2階以上に居室設置 緩和 延べ面積が100㎡以内のものは避難室、避難設備の設置による代替可		*公共建築物の制限 (第2種～第4種区域) 範囲…学校、病院、集会場、官公署、児童福祉施設等その他これらに類する公共建築物 制限…1階の床の高さN・P(+)2mかつN・P(+)3.5m以上の居室設置
第3種区域	市街化区域	N・P(+)1m以上	――		
第4種区域	市街化調整区域	N・P(+)1m以上	2階以上に居室設置		

Shift to community planning resistant to inundation

○Adopting pilotis to prevent damage to buildings during a flood

(ii) Adaptation measures centering around risk management

Building of a wide-area disaster prevention network that connects embankments, roads on the dry river bed for emergency traffic and elevated roads to wide-area disaster prevention bases.



Network of roads and river embankments

Inundation of Route 34 during a flood in July 1990

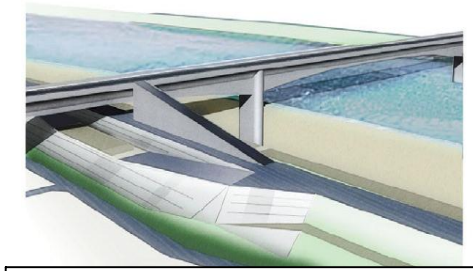
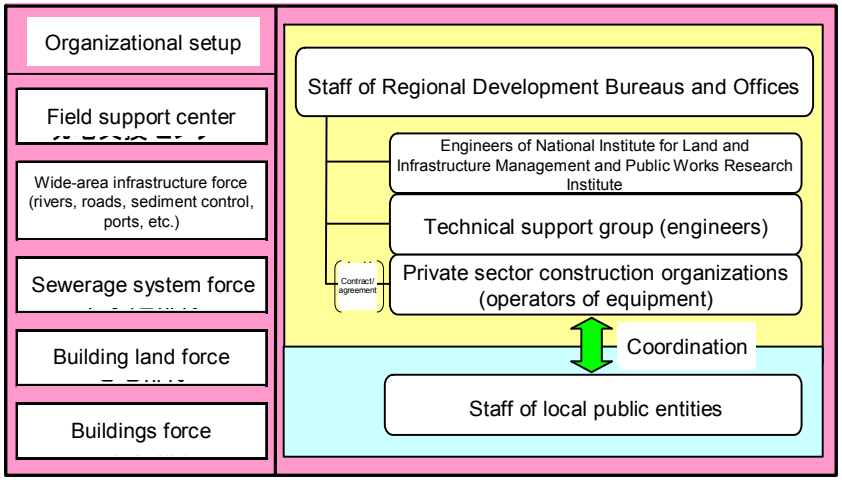


Image of road-embankment connection

Reinforcement of actions in the initial stages of a disaster for minimizing damage and restoring infrastructure early, and enhancement of an organizational setup to achieve the goal

Technical Emergency Control Force (TEC-FORCE)

TEC-FORCE



Activities
-Investigation of damage
-Quick fix
-Prediction of degree of damage risk
-Planning of control measures
-High-level technical guidance
-Assistance in reconstruction

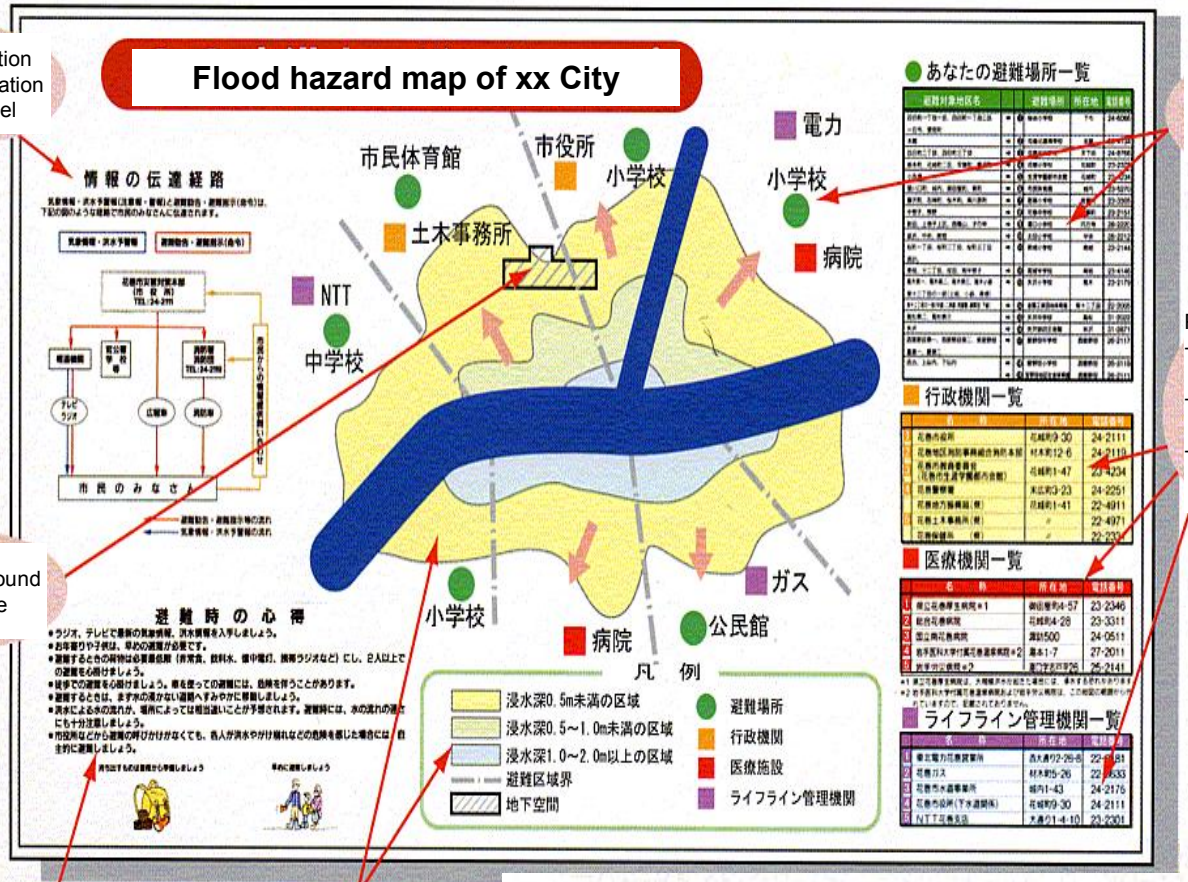
Drainage pumping vehicle

Disaster control helicopter

Adaptation measures based on risk management

Share preliminary information concerning the degree of flood risk

Water levels in built-up areas in the past floods are indicated on the hazard map.



Information dissemination channel

Underground space

Hints on escape and necessities

Potential inundation areas and depths of inundation

Locations and names of shelters

Points of contact
-Administrative organizations
-Medical institutions
-Lifeline systems management organizations

Image of a flood hazard map

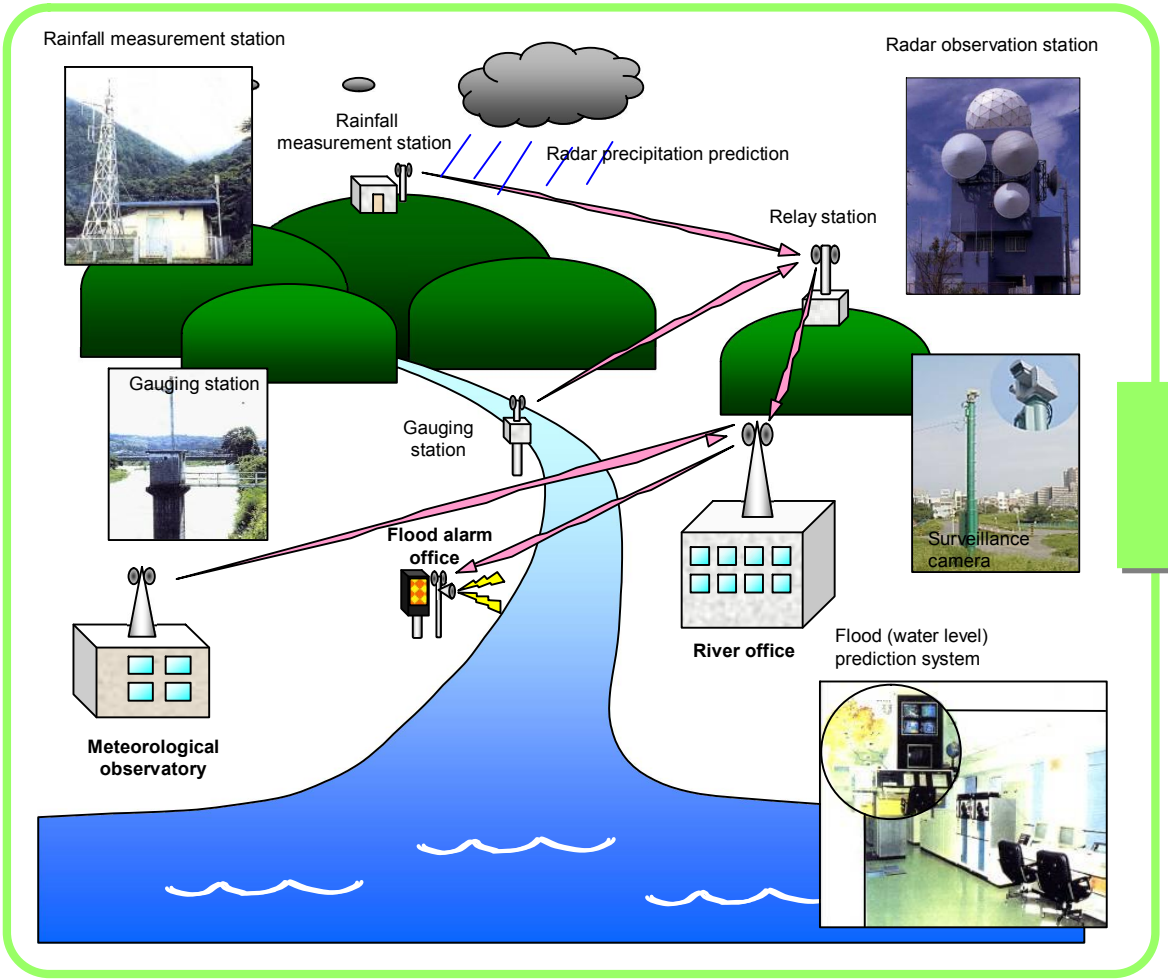
Toyooka City, Hyogo Prefecture

Easily recognizable signs

Adaptation measures based on risk management

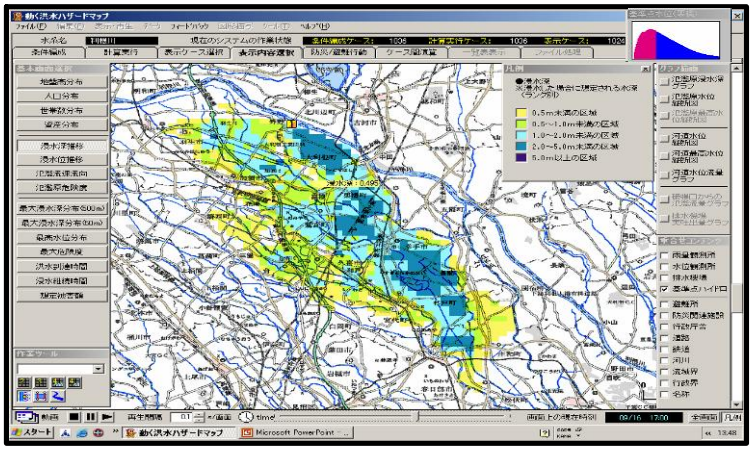
Share real-time information

- Provision of rainfall amounts and water levels real-time via cellular phone, the Internet or local disaster prevention radio
- Flood forecasting through real-time simulation



Information provision via cellular phone or personal computer

Delivery of an image to a TV screen



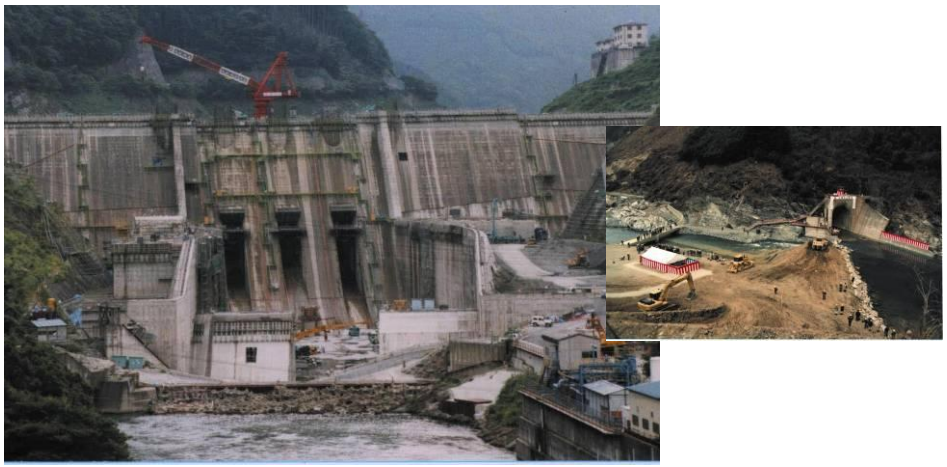
Floodwater prediction through real-time simulation

Facilities-based adaptation measures

Development of new facilities including the construction of new embankments, widening of river channels and construction of flood-regulating dams; and maximum use of existing facilities

Development of new facilities

Development of a river channel



Construction of a flood-regulating dam

Effective use or prolonging of the life of an existing facility (removal of sediment from an existing reservoir)

Example: Yokoyama Dam

Facilities-based adaptation measures

Improvement of reliability, effective use, use for multiple purposes and prolonging of lives of existing facilities

Improving the reliability of an existing facility (a coastal facility)

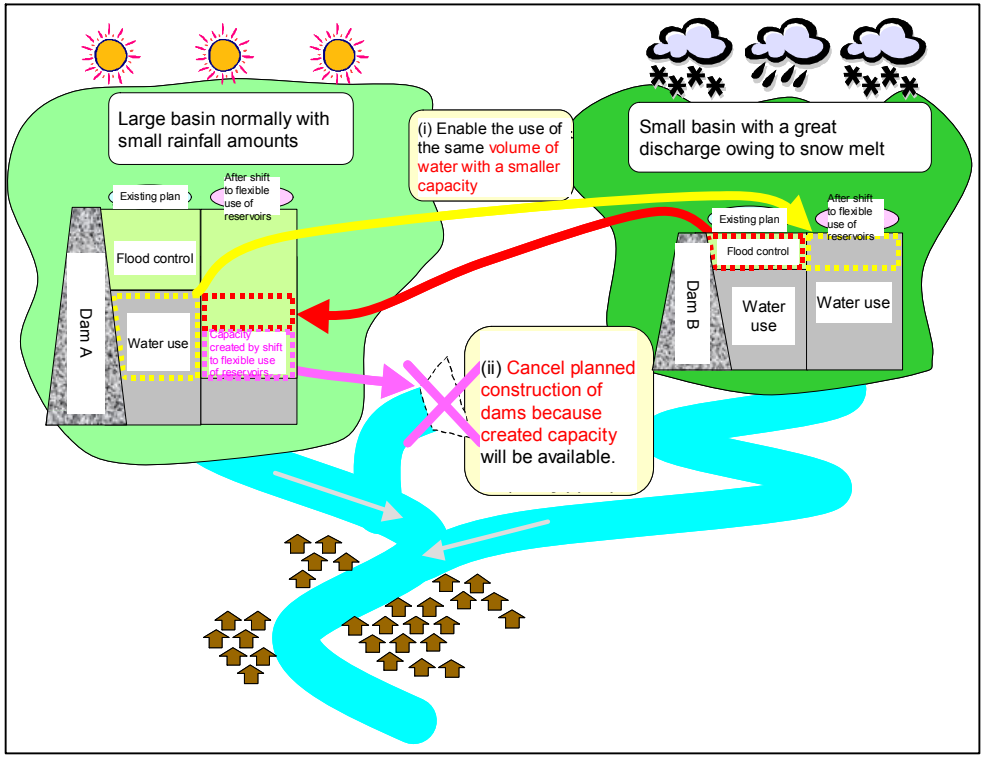
Before improvement

Revetment with deteriorated concrete

After improvement

Revetment with increased thickness

Effective use of existing facilities (flexible use of reservoirs)



Flexible use of reservoirs
- Use the capacity for water use of the existing reservoir for controlling floods
- Flexible use of combined capacity of existing and newly constructed reservoirs

Increase the effectiveness for flood control and safety against floods

Outline of discussions at the First Asia-Pacific Water Summit

The Summit was held under the theme of Water Security: Leadership and Commitment. Ten sessions were held under three main themes: Water infrastructure and human resources development, water-related disaster management and water for development and ecosystems.

"Message from Beppu", a summary of two-day discussions, was issued.

- ✓Top priority will be given to water and sanitation in economic, development and political activities in each country in the Asia-Pacific region and assistance will be enhanced.
- ✓Effective actions will be taken promptly to prevent or reduce floods, droughts and other water-related disasters and to save or assist victims on a timely basis.
- ✓Assistance will be provided urgently to island countries,which are vulnerable to the impacts of climate change, to help them protect human lives and property.
- ✓Some countries have already been witnessing the impacts of climate change such as the melting of snow caps and glaciers in the Himalayas, and sea level rise. The Message suggests that the UN Conference on Climatic Change meeting in Bali put the relationship between water and climate change on the agenda.

- ➢Leaders in the Asia-Pacific region had full-scale discussions about the adaptation measures for reducing the risk of climate change.
- ➢Leaders in the Asia-Pacific region faced with challenges in relation to water got together and re-confirmed their understanding that solving water-related problems is the top priority.

Address by His Imperial Highness the Crown Prince of Japan (excerpts)

- Water poses serious problems in relation to climate change. There is the fear that global warming is likely to have various adverse impacts on people's activities such as sea level rise, frequent abnormal weather conditions, more severe disasters and large-scale water shortages. There have recently been more heavy rains throughout the world and wider areas have been subjected to the impacts of droughts. I feel great sorrow for the heavy damage caused by water-related disasters that have been occurring frequently in the Asia-Pacific region.
- Water-related issues are intertwined. Water supply, sanitation and flood control are not independent of one another. To deal with the issues, it is important to understand the diverse characteristics of water from the widest viewpoint possible and to take step-by-step approach suitable to the regional conditions based on a comprehensive perspective and through the innovative and cooperative efforts of those concerned

Address by Prime Minister Yasuo Fukuda of Japan (excerpts)

-The Asia-Pacific Region, although enjoying prosperity, is faced with various water-related issues. We are in a serious situation as the majority of world's water-related issues are concentrated in the region.

-Water-related disasters attributable to climate change have been increasing and are expected to have great impacts. We need to take measures urgently to control water-related disasters.

-Global climate change substantially impacts humankind through water.

-Building an international framework is an immediate task. I will raise environmental and climate change issues as the main topic on the agenda at next year's G8 Hokkaido Toyako Summit.

-The vigorous discussions at the Asia-Pacific Water Summit will provide great momentum and wisdom to the G8 Summit.

Source: Website of Prime Minister's Office